#### **4.1. Transaction processing**

In this lecture we look at... [Section notes PDF 86Kb]

#### **4.1.01. Distributed Databases**

- Transactions
- Unpredictable failure

   Commit and rollback
- Stored procedures
- Brief PL overview
  - Cursors

#### **4.1.02.** Transactions

- Real world database actions
- Rarely single step
- Flight reservation example
  - o Add passenger details to roster
  - o Charge passenger credit card
  - Update seats available
  - Order extra vegetarian meal

## 4.1.04. Desirable properties of transactions

## ACID test

- <u>A</u>tomicity
  - o transaction as smallest unit of processing
  - transactions complete entirely or not at all
    - consequences of partial completion in flight example
- <u>C</u>onsistency
  - o complete execution preserves database constrained state/integrity
  - e.g. Should a transaction create an entity with a foreign key then the reference entity must exist (see 4 constraints)

## 4.1.05. ACID test continued

- Isolation
  - o not interfered with by any other concurrent transactions
- Durable (permanency)
  - commited changes persist in the database, not vulernable to failure

## 4.1.06. Commit

- Notion of Commit (durability)
- Transaction failures
  - From flight reservation example
    - Add passenger details to roster
    - Charge passenger credit card
    - Update seats available: No seats remaining
    - Order extra vegetarian meal
- Rollback

## 4.1.07. PL/SQL overview

- Language format
  - Declarations
  - $\circ$  Execution
  - Exceptions
  - Handling I/O
  - Functions
  - $\circ$  Cursors

# 4.1.08. PL/SQL

- Blocks broken into three parts
  - $\circ$  Declaration
    - Variables declared and initialised
  - $\circ$  Execution
    - Variables manipulated/actioned
  - Exception
    - Error raised and handled during exec
  - DECLARE

```
---declarations
BEGIN
---statements
EXCEPTION
---handlers
END ;
```

# 4.1.09. Declaration

- DECLARE
  - age NUMBER;
  - $\circ$  name VARCHAR(20);
  - surname employee.fname%TYPE;
  - addr student.termAddress%TYPE;

# 4.1.10. Execution

- BEGIN (not in order)
  - /\* sql\_statements \*/
    UPDATE employee SET salary = salary+1;
  - o /\* conditionals \*/
    - IF (age < 0) THEN
      - age: = 0;
    - ELSE
      - age: = age + 1;
    - END IF;
  - /\* transaction processing \*/
  - COMMIT; ROLLBACK;
     /\* loops \*/ /\* cursors \*/
- [END;] (if no exception handling)

## 4.1.11. Exception passing

- Beginnings of PL I/O
- CREATE TABLE temp (logmessage varchar(80));
   Can create transfer/bridge relation outside
- Within block (e.g. within exception handler)
  - WHEN invalid\_age THEN
    - INSERT INTO temp VALUES( 'Cannot have negative ages');
  - END;
  - SELECT \* FROM temp;
    - To review error messages

## 4.1.12. Exception handling

- DECLARE
  - invalid\_age exception;
- BEGIN
  - $\circ$  IF (age < 0) THEN
    - RAISE invalid\_age
  - END IF;
- EXCEPTION
  - WHEN invalid\_age THEN
    - INSERT INTO temp VALUES( 'Cannot have negative ages');
  - END;

# **4.1.13.** Cursors

- Cursors
  - o Tuple by tuple processing of relations
  - Three phases (two)
    - Declare
    - Use

• Exception (as per normal raise)

#### 4.1.14. Impact

- PL blocks coherently change database state
- No runtime I/O
- Difficult to debug
- SQL tested independently

# 4.1.15. PL Cursors

- DECLARE
- name\_attr EMPLOYEE.NAME%TYPE;
- ssn\_attr EMPLOYEE.SSN%TYPE;
- /\* cursor declaration \*/
- CURSOR myEmployeeCursor IS
  - SELECT NAME,SSN FROM EMPLOYEE
    - WHERE DNO=1
    - FOR UPDATE;
- emp\_tuple myEmployeeCursor%ROWTYPE;

## 4.1.16. Cursors execution

- BEGIN
- /\* open cursor \*/
- OPEN myEmployeeCursor;
- /\* can pull a tuple attributes into variables \*/
- FETCH myEmployeeCursor INTO name\_attr,ssn\_attr;
- /\* or pull tuple into tuple variable \*/
- FETCH myEmployeeCursor INTO emp\_tuple;
- CLOSE myEmployeeCursor;
- [LOOP...END LOOP example on handout]

# **4.1.17. Concurrency Introduction**

- Concurrent transactions
- Distributed databases (DDB)
- Fragmentation
- Desirable transaction properties
- Concurrency control techniques
  - $\circ$  Locking
  - Timestamps

## **4.1.18.** Notation

- Language
  - PL too complex/long-winded
- Simplified database model
  - Database as collection of named items
  - $\circ~$  Granularity, or size of data item
  - Disk block based, each block X
- Basic transaction language (BTL)
  - o read\_item(X);
  - o write\_item(X);
  - Basic algebra, X=X+N;

## 4.1.19. Transaction processing

- DBMS Multiuser system
  - Multiple terminals/clients
    - Single processor, client side execution
  - Single centralised database
    - Multiprocessor, server
    - Resolving many transactions simultaneously
- Concurrency issue
  - Coverage by previous courses (e.g. COMS12100)
  - PL/SQL scripts (Transactions) as processes
- Interleaved execution

#### 4.1.20. Transactions

- Two transactions, T<sub>1</sub> and T<sub>2</sub>
- Overlapping read-sets and write-sets
- Interleaved execution
- Concurrency control required
- PL/SQL example
  - Commit; and rollback;

## 4.1.21. Concurrency issues

- Three potential problems
  - Lost update
  - Dirty read
  - Incorrect summary
- All exemplified using BTL
  - Transaction diagrams to make clearer
  - C-like syntax for familiarity
  - Many possible examples of each problem

## 4.1.22. Lost update

```
T<sub>1</sub>
read_item(X);
X=X-N;
```

 $T_2$ 

write\_item(X);

read\_item(Y);

read\_item(X); X=X+M;

• T<sub>1</sub> X update

write\_item(X);

T<sub>2</sub>

Y=Y+N;write\_item(Y);

#### overwritten

#### **4.1.23.** Dirty read (or Temporary update)

T<sub>1</sub> read\_item(X); X=X-N;write\_item(X);

read\_item(X); X=X+M;write\_item(X);

 $<T_1$  fails>  $< T_1$  rollback>

read\_item(X); X=X+N;write\_item(X);

• T<sub>2</sub> reads temporary incorrect value of X

# 4.1.24. Incorrect summary

T <sub>1</sub>	T <sub>2</sub>
	sum=0;
	read_item(A)
read_item(X);	sum=sum+A;
X=X-N;	
write_item(X);	
	read_item(X);
	sum=sum+X;
read_item(Y);	read_item(Y);
Y=Y-N;	sum=sum+Y;
<pre>write_item(Y);</pre>	

• T<sub>2</sub> sums after X-N and before Y-N

## 4.1.25. Serializability

- Schedule S is a collection of transactions (T<sub>i</sub>)
- Serial schedule S<sub>1</sub>
  - o Transactions executed one after the other
  - Performed in a serial order
  - No interleaving

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- $\circ$  Commit or abort of active transaction (T<sub>i</sub>) triggers execution of the next (T<sub>i+1</sub>)
- If transactions are independent
  - all serial schedules are correct

## 4.1.26. Serializability

- Serial schedules/histories
  - No concurrency
  - Unfair timeslicing
- Non-serial schedule S<sub>2</sub> of n transactions
  - Serializable if
- equivalent to some serial schedule of the same n transactions

   correct
- n! serial schedules, more non-serial

#### 4.1.27. Distribution

- DDB, collection of
  - o multiple logically interrelated databases
  - o distributed over a computer network
  - o DDBMS
- Multiprocessor environments
  - Shared memory
  - Shared disk
  - Shared nothing

#### 4.1.28. Advantages

- Distribution transparency
  - Multiple transparency levels
  - Network
  - Location/dept autonomy
  - o Naming
  - Replication
  - Fragmentation
- Reliability and availability
- Performance, data localisation
- Expansion

# 4.1.29. Fragmentation

- Breaking the database into
  - $\circ$  logical units
  - for distribution (DDB design)
- Global directory to keep track/abstract
- Fragmentation schema/allocation schema

   Relational

- Horizontal
  - Derived (referential), complete (by union)
- o Vertical
- $\circ$  Hybrid

#### **4.1.30.** Concurrency control in DDBs

- Multiple copies
- Failure of individual sites (hosts/servers)
- Failure of network/links
- Transaction processing
  - Distributed commit
  - Deadlock
- Primary/coordinator site voting

#### 4.1.31. Distributed commit

- Coordinator elected
- Coordinator prepares
  - writes log to disk, open sockets, sends out queries
- Process
  - o Coordinator sends 'Ready-commit' message
  - Peers send back 'Ready-OK'
  - Coordinator sends 'Commit' message
  - $\circ\,$  Peers send back 'Commit-OK' message

# 4.1.32. Query processing

- Data transfer costs of query processing
  - Local bias
  - High remote access cost
  - Vast data quantities to build intermediate relations
- Decomposition
  - Subqueries resolved locally

## 4.1.33. Concurrency control

- Must avoid 3+ problems
  - Lost update, dirty read, incorrect summary
  - Deadlock/livelock dining example
- Data item granularity
- Solutions
  - o Protocols, validation
  - $\circ \ Locking$
  - Timestamps

# **4.1.34. Definition of terms**

- Binary (two-state) locks
- locked, unlocked associated with item X
- Mutual exclusion
- Four requirements
  - Must lock before access
  - o Must unlock after all access
  - No relocking of already locked
  - $\circ~$  No unlocking of already unlocked

#### 4.1.35. Definition

- Multiple mode locking
- Read/write locks
- aka. shared/exclusive locks
- Less restrictive (CREW)
- read\_lock(X), write\_lock(X), unlock(X)
  - $\circ$  e.g. acquire read/write\_lock
    - o not reading or writing the lock state

#### 4.1.36. Rules of Multimode locks

- Must hold read/write\_lock to read
- Must hold write\_lock to write
- Must unlock after all access
- Cannot upgrade/downgrade locks
  - Cannot request new lock while holding one
- Upgrading permissable (read lock to write) • if currently holding sole read access
- Downgrading permissable (write lock to read)
  - if currently holding write lock